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DECISION UNDER CONFLICT:
Resolution and Confidence in Judgment and Choice

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The major themes of the research supported under this grant are the discrepancy between normative and descriptive theory and the constructive nature of decision and judgment. In contrast to the classical theory that treats preferences as given and describes choice as a maximization process, the present approach holds that preferences and judgments are often constructed -- not merely revealed -- in the elicitation process. Furthermore, these constructions are contingent on the framing of the problem, the method of elicitation, and the context of choice.

During the last three years, my collaborators and myself have made considerable progress towards the development of a constructive analysis of choice, documented in the enclosed articles. The present report reviews the major themes, organized under six headings: (1) Resolving Conflict; (2) Reference-dependent Theory; (3) The Aggregate/Individual Discrepancy; (4) Elicitation Effects and the Compatibility Principle; (5) Preference and Belief; and (6) Evidence and Confidence. These topics are discussed in turn. For details, the reader is referred to the enclosed papers, which are numbered for easy reference.

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1. Resolving Conflict

The making of decisions, both big and small, is often difficult because we do not know how to resolve the conflict that arises from the need to give up one goal or asset (e.g., leisure) in order to attain another (e.g., financial security). The resolution of conflict is typically made more difficult by the presence of uncertainty about the state of the world as well as about our own state of mind. In contrast to classical decision theory, in which conflict does not play any role, we maintain that the presence of conflict influences not only the psychological state of the decision maker; it also affects actual choice. More specifically, we have shown that the option to delay choice or seek new alternatives is more likely to be selected when conflict is high than when it is low, contrary to the principle of value maximization (Tversky & Shafir, "Choice under conflict: The dynamics of deferred decision, *Psychological Science*, 1992, in press, #1). This article also shows that the more time people had to complete a task, the less likely they were to do so. Just as the addition of options enhances the tendency to defer decision, the addition of time can enhance the tendency to delay action.

One of the basic principles of the rational theory of decision under uncertainty (called the sure-thing principle, or STP) states that if prospect X is preferred to Y knowing that event A occurred, and if X is preferred to Y knowing that A did not occur, then X should be preferred to Y even when it is not known whether A occurred. We argue that, despite its intuitive appeal, STP may not hold in situations of conflict in which the decision maker has a good reason for accepting X if A occurs, and different reasons for accepting X if A does not occur. Not knowing whether or not A occurs, however, the decision maker may lack a clear reason for accepting X and may opt for another option (Tversky & Shafir, "The disjunction effect in choice under

uncertainty," *Psychological Science*, 1992, in press, #2). In the presence of uncertainty, people are often reluctant to think through the implications of each outcome and, as a result, violate STP. We have extended this analysis from games against nature to games against an intelligent opponent (Shafir & Tversky, "Thinking through uncertainty: Nonconsequential reasoning and choice," *Cognitive Psychology*, 1992, in press, #3). In the Prisoner's Dilemma game, for example, many subjects compete when they know that the opponent has competed and when they know that the opponent has cooperated, but cooperate when they do not know the opponent's response, contrary to STP. We have also applied this analysis to the study of reasoning, and showed that it can help explain some puzzling phenomena, such as people's inability to solve Wason's selection problem.

2. Reference-dependent Theory

The rational theory of decision making under both risk and uncertainty -- which underlies much of economics, decision analysis, and management science -- assumes that preference between options depends on one's tastes, but not on one's reference state. Consequently, the carriers of utility are final asset positions, not gains or losses. Although this assumption has considerable normative appeal, the evidence indicates that the outcomes of choice are normally perceived as gains and losses defined relative to a reference point, rather than final asset positions. This assumption serves as the cornerstone of our theoretical analyses of both risky and riskless choice, which are sketched below.

Decision under risk. More than a decade ago, Daniel Kahneman and myself proposed a theory of choice, called prospect theory, which explained the major violations of expected utility theory in choice between risky prospects with a small number of outcomes. We have now

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developed a new version of the theory, called cumulative prospect theory, using cumulative rather than separable decision weights (Tversky & Kahneman, "Advances in prospect theory: Cumulative representation of uncertainty," *Journal of Risk and Uncertainty*, 1992, in press, #4). The new theory extends the original model in several important respects. First, it applies to prospects with many outcomes and it can be readily extended to continuous distributions. Second, it is not limited to prospects with objective probabilities, and it can be applied to unquantified uncertainty as well. Third, the present theory allows different decision weights for gains and for losses. Two principles, diminishing sensitivity and loss aversion, are invoked to explain the characteristic curvature of the value function and the weighting functions. Perhaps the most distinctive prediction of the theory is the fourfold pattern of risk attitudes: risk aversion for gains and risk seeking for losses of high probability; risk seeking for gains and risk aversion for losses of low probability. This prediction was confirmed in an extensive experimental study of risky choice.

Decision under certainty. Our analysis of value is based on three essential characteristics. Reference dependence: the carriers of value are gains and losses defined relative to a reference point. Loss aversion: the value function is steeper than in the positive domain; losses loom larger than corresponding gains. Diminishing sensitivity: marginal value of both gains and losses decreases with their size. These properties give rise to an asymmetric S-shaped value function, concave above the reference point and convex below it, which plays a central role in both the original and the new versions of prospect theory. The same principles also serve as a basis for our theory of riskless choice between multi-attribute alternatives (Tversky & Kahneman, "Loss aversion in riskless choice: A reference-dependent model," *Quarterly Journal of Economics*, 1991, #5).

This article presents a series of experimental demonstrations of loss aversion in riskless choice. In particular, we show that the amount of money required to compensate the decision maker for a change in the level of a given attribute is higher when the change represents a loss than when it represents a gain. Because gains and losses are defined relative to the reference state, a shift of reference can change the sign of the respective outcomes and lead to a reversal of preference. Thus, X may be preferred to Y from reference state R, whereas Y is preferred to X from reference state S. To explain these phenomena, we generalize the standard theory by introducing a reference-dependent relation of preference that incorporates the notion of loss aversion. A particular form of loss aversion, called constant loss aversion, is defined as a change of unit below the reference point. A review of the experimental evidence suggests that choices involving monetary outcomes and consumption goods yield a loss aversion coefficient of about two. That is, the impact of a given difference is doubled when it represents a loss instead of a gain.

Loss aversion has far-reaching implications for both individual and aggregate behavior. It underlies the large discrepancy, reported in the economic literature, between the minimal amount that people are willing to accept to give up a given object and the maximum amount that they are willing to pay to acquire it. Furthermore, because a change generally involves a gain in one attribute and a loss on another, loss aversion favors stability over change. Loss aversion can also shed light on the difficulty of reaching a negotiated settlement. If each side views its own concession as a loss and the concession made by the opponent as a gain, then loss aversion will make mutual concession relatively unattractive (see Kahneman & Tversky, "Conflict resolution: A cognitive perspective," forthcoming, #6).

3. The Aggregate/Individual Discrepancy

Decision makers often face independent uncertain prospects that are repetitive in character. For example, a gambler may play the same game many times in an evening, an entrepreneur may encounter several comparable business ventures over time, and a physician may treat many patients with similar problems in the course of practice. We have investigated how physicians and laypeople make decisions involving multiple prospects. Our study indicates that physicians make different decisions when evaluating an individual patient than when considering a group of comparable patients (Redelmeier & Tversky, *New England Journal of Medicine*, 1990, #7). This discrepancy is recognized as a professional norm and is also found in the judgments of laypeople. Presented with the individual -- as compared to the aggregate -- perspective, the physicians in our study were more likely to order an additional test, spend more time assessing a patient, and recommend a therapy which combines a high probability of success with some chance of an adverse outcome.

We also investigated the manner in which people frame multiple prospects. At the extremes, a decision maker may either consider each prospect as a separate event (segregation) or evaluate the overall distribution of outcomes (aggregation). We found that people sometimes reject a single gamble but accept a repeated play, contrary to choice by segregation. On the other hand, people tend to choose by segregation when a particular prospect is singled out from a larger ensemble (Redelmeier & Tversky, "On the framing of multiple prospects," *Psychological Science*, 1992, #8).

4. Elicitation Effects and the Compatibility Principle

One of the major empirical findings that calls for a constructive approach is the dependence of choice on the method of elicitation. There is a large body of evidence showing that strategically equivalent methods of elicitation give rise to systematically different responses, contrary to the standard theory in which the decision maker is assumed to have a well-defined preference order that can be elicited using different procedures. To account for these data within a constructive framework, we seek explanatory principles that relate the characteristic of the task to the attributes of the objects under study. One such notion is the compatibility hypothesis, which states that the weight of the stimulus attribute is enhanced by its compatibility with the response. The rationale for this hypothesis is twofold. First, if the input and output are noncompatible, additional mental operations are required, and these tend to increase effort and error and reduce impact. Second, a response mode tends to focus attention on the compatible features of the stimulus. We have investigated the compatibility principle directly, and used it to explain elicitation effects in judgment and choice (Slovic, Griffin, & Tversky, "Compatibility effects in judgment and choice," in *Insights in decision making*, R.N. Hogarth, editor, 1990, #9).

We have demonstrated the compatibility principle in predictions of market value and course grade. In each case, the weight of the stimulus attribute was greater when it matched the response scale than when it did not. The significance of the compatibility principle stems from its ability to explain the well-known preference reversal phenomena, which has puzzled psychologists and economists for more than two decades. When faced with a choice between a prospect that has a high chance of winning a relatively small prize and a prospect with comparable expected value that offers a low probability to win a larger prize, subjects generally

prefer the former over the latter, but assign a higher cash equivalent to the latter than to the former. Although the preference reversal phenomena has been replicated in many studies, its causes have remained elusive. Using a novel experimental design and a new diagnostic procedure, we were able to exclude several common interpretations of this phenomenon as a violation of transitivity, of the independence axiom, or of the reduction axiom of expected utility theory. Instead, it appears that the great majority of preference reversals are produced by a violation of procedure invariance, and more specifically, by an overpricing of the low probability bet (see Tversky, Slovic, & Kahneman, "The causes of preference reversal," *American Economic Review*, 1990, #10).

Because the cash equivalent of a bet is expressed in dollars, compatibility implies that the payoffs, which are expressed in the same units, will be weighted more heavily in pricing than in choice. The compatibility principle also predicts a new type of reversal involving temporal prospects. When faced with delayed payments with roughly comparable present value, subjects generally preferred the short-term payment over the long-term payment, but priced the latter higher than the former. We explored the implications of preference reversal to the analysis of decision making (Tversky & Thaler, "Preference reversal," *Journal of Economic Perspective*, 1990, #11).

5. Preference and Belief

Classical decision theory assumes that the preference between uncertain prospects depends on the degree of uncertainty but not on its source. If the decision maker regards two propositions as equally likely he or she should be equally willing to bet on either one. This assumption, however, is inconsistent with the results of numerous experiments showing that

people prefer to bet on some sources of uncertainty rather than on others. Within a chance setup, people generally prefer to bet on known rather than unknown probabilities, but this does not hold for evidential problems in general. People often prefer to bet on their skill rather than on a matched chance event, even though the former is vaguer than the latter.

In order to account for these observations, we have introduced a new account, called the competence hypothesis (Heath & Tversky, "Preference and belief: Ambiguity and competence in choice under uncertainty," *Journal of Risk and Uncertainty*, 1991, #12). This hypothesis states that, holding degree of belief or judged probability constant, people prefer to bet in a context where they consider themselves knowledgeable or competent than in a context where they feel ignorant or uninformed. We assume that the feeling of competence in a given context is enhanced by general knowledge, familiarity, and experience, and it is diminished, for example, by calling attention to relevant information that is not available to the decision maker, especially if it is available to others. This hypothesis is supported in a series of experiments showing that people prefer betting on their own judgments over an equiprobable chance event when they consider themselves knowledgeable, but not otherwise. They even pay a significant premium to bet on their judgments. These data cannot be explained by aversion to ambiguity, because judgmental probabilities are more ambiguous than chance events. This conclusion challenges the idea of using preferences to infer beliefs. For if people's willingness to act depends not only on their degree of uncertainty (and the precision with which it is measured) but also on one's sense of competence concerning a particular domain, it is exceedingly difficult, if not impossible, to derive underlying belief from observed preferences.

6. Evidence and Confidence

The weighing of evidence and the assessment of confidence are basic elements of human judgment. Confidence is important because it mediates between action and belief. People generally act on beliefs that are held with a high degree of confidence and are reluctant to act in the presence of doubt. Overconfidence or underconfidence, therefore, can lead to inappropriate action. We have proposed that the pattern of overconfidence and underconfidence observed in studies of intuitive judgment is explained by the hypothesis that people focus on the strength or extremeness of the available evidence (e.g., the warmth of a letter of recommendation, or size of an effect) with insufficient regard for its weight or credence (the credibility of the writer or the size of the sample). This mode of judgment yields overconfidence when strength is high and weight is low and underconfidence when strength is low and weight is high (Griffin & Tversky, "The weighing of evidence and the determinants of confidence," *Cognitive Psychology*, 1992, #13).

The predicted pattern was demonstrated in a chance setup where strength is defined by sample proportion and weight is defined by sample size. It was also observed in more complex evidential problems involving general knowledge, and predictions of the behavior of self and of others. We proposed that people's confidence is determined by the balance of arguments for and against the competing hypotheses, with insufficient regard for the weight of the evidence. This account can explain the effect of item difficulty on overconfidence and is consistent with the observed discrepancy between confidence judgments and frequency estimates.

Judgments of probability are commonly evaluated by two criteria: calibration, namely the correspondence between stated confidence and rate of occurrence; and resolution, namely the ability to distinguish between events that do and do not occur. We distinguish between two representations of probability judgments: the designated form that presupposes a particular coding of outcomes (e.g. rain versus no rain), and the inclusive form that incorporates all events and their complements (Lieberman & Tversky, "On the evaluation of probability judgments: Calibration, resolution and monotonicity," *Psychological Bulletin*, 1992, forthcoming, #13). We have shown that the indices of calibration and resolution derived from the designated and the inclusive representations measure different characteristics of judgment, and that the values of the designated indices depend on the coding of outcomes. We have also developed an ordinal measure of resolution that treats probability judgments as an ordinal rather than cardinal scale. Calibration is distinguished from two types of overconfidence: specific and generic. Although all three phenomena represent biased assessments, it is important to distinguish among them because they have different causes and different implications.

References

- Griffin, D., & Tversky, A. (1992). The weighing of evidence and the determinants of confidence. *Cognitive Psychology*, 24, 411-435.
- Heath, F., & Tversky, A. (1991). Preference and Belief: Ambiguity and competence in choice under uncertainty. *Journal of Risk and Uncertainty*, 4, 4-28.
- Kahneman, D., & Tversky, A. (1992). Conflict resolution: A cognitive perspective. In K. Arrow, R. Mnookin, L. Ross, A. Tversky, & R. Wilson (Eds.), *Barriers to conflict resolution*. New York: Norton. forthcoming.
- Lieberman, V., & Tversky, A. (1992). On the evaluation of probability judgments: Calibration, resolution and monotonicity. *Psychological Bulletin*, .forthcoming.
- Redelmeier, D., & Tversky, A. (1990). Discrepancy between medical decisions for individual patients and for groups. *New England Journal of Medicine*, 322, 1162-1164.
- Redelmeier, D., & Tversky, A. (1992). On the framing of multiple prospects. *Psychological Science*, 3(3), 191-193.
- Shafir, E., & Tversky, A. (1992). Thinking through uncertainty: Nonconsequentialism in reasoning and choice. *Cognitive Psychology*, .forthcoming.
- Slovic, P., Griffin, D., & Tversky, A. (1989). Compatibility effects in judgment and choice. In R. M. Hogarth (Ed.), *Insights in decision making: Theory and applications*. Chicago: The University of Chicago Press:

- Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference dependent model. *Quarterly Journal of Economics*, 107(4), 1039-1061.
- Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, forthcoming.
- Tversky, A., & Shafir, E. (1992a). Choice under conflict: The dynamics of deferred decision. *Psychological Science*, .
- Tversky, A., & Shafir, E. (1992b). The disjunction effect in choice under uncertainty. *Psychological Science*, .
- Tversky, A., Slovic, P., & Kahneman, D. (1990). The causes of preference reversal. *American Economic Review*, 80, 204-217.
- Tversky, A., & Thaler, R. (1990). Anomalies: Preference reversals. *Journal of Economic Perspectives*, 4(2), 201-211.